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(54) [Title of the Invention] WAFER FOR SEMICONDUCTOR DEVICE  
AND METHOD OF MANUFACTURING THE SAME

(57) Abstract

[Object] To provide a wafer for a semiconductor device, in which only an operation layer can be easily removed from a grown substrate without damaging the operation layer, and a method capable of manufacturing the semiconductor device with a high yield by use of the wafer.

[Constitution] Provided is a wafer for a semiconductor device characterized in that a buffer layer formed of a layered compound having an excellent cleavage is provided between a grown substrate and an operation layer. Furthermore, provided is a method of manufacturing the semiconductor device, in which after the buffer layer formed of the layered-like compound having the excellent cleavage is formed on the grown substrate, the operation layer is epitaxially grown on the buffer layer, and the operation layer and the grown substrate are peeled off from each other, thus the operation layer is joined to a supporting substrate for the semiconductor device.

[Scope of claims]

[Claim 1] A wafer for a semiconductor device having an epitaxial operation layer on a grown substrate, the wafer for a semiconductor device being characterized in that a buffer layer formed of a layered compound having an excellent cleavage is provided between a grown substrate and an operation layer.

[Claim 2] A method of manufacturing a semiconductor device having an epitaxial operation layer, the method being characterized in that after a buffer layer formed of a layered-like compound having an excellent cleavage is formed on a grown substrate, an operation layer is epitaxially grown on the buffer layer, and the operation layer and the grown substrate are peeled off from each other, thus the operation layer is joined to a supporting substrate for the semiconductor device.

[Claim 3] A method of manufacturing a semiconductor device having an epitaxial operation layer, the method being characterized in that a buffer layer formed of a layered

compound having an excellent cleavage is formed on a grown substrate; the grown substrate is exposed by removing at least a part of the buffer layer except for a device formation region; an operation layer is epitaxially grown on an exposed portion of the grown substrate and the buffer layer; only the device formation region is cut to be taken out; and the operation layer in the device region is peeled off from the grown substrate to be jointed to a supporting substrate for the semiconductor device.

[Detailed Description of the Invention]

[0001]

[Field of Industrial Applicability] The present invention relates to a wafer for a semiconductor device suitable for a high output semiconductor device, an infrared image pick-up device, which has no growth substrate of a compound semiconductor, and a method of manufacturing a semiconductor device.

[0002]

[Prior Art] Conventionally, an epitaxial wafer used for a semiconductor device has a structure in which an operation layer and a buffer layer having the same crystal structure as that of a grown substrate are laminated on a substrate, as shown, for example, in Science Forum "Latest Compound Semiconductor Handbook", pages 313 to 323, issued on July 10, 1982. In this device, in order to reduce a heat resistance of the device, the grown substrate and the buffer layer need to be made as thin as possible, or they need to be removed thoroughly. Furthermore, in an infrared image pick-up device, a substrate serving as an absorption layer of light needs to be removed thoroughly, as shown in the foregoing Handbook, pages 349 to 350.

[0003]

[Problem to be Solved by the Invention] Conventionally, an epitaxial wafer of such a kind is composed of an operation layer, a buffer layer and a grown substrate, which have the same crystal structure. Fig. 5 is a sectional view of the conventional epitaxial wafer, which is a wafer composed of a buffer layer 9 epitaxially grown on a compound semiconductor grown substrate 8, and an operation layer 10 epitaxially grown thereon. In order to obtain such operation layer from the wafer, the grown substrate, or the buffer layer and the grown substrate, was removed from the operation layer by polishing or etching. It was very difficult to uniformly remove the grown substrate, or the buffer layer and the grown substrate, which have the same crystal structure, without breaking the operation layer. Accordingly, the present invention is to provide a wafer for a semiconductor device with which the foregoing drawbacks are solved, and in which the grown substrate is removed without breaking the operation layer, and to provide a method of manufacturing a semiconductor device using the wafer.

[0004]

[Means for Solving the Subjects] (1) The present invention is a wafer for a semiconductor device having an epitaxial operation layer on a substrate, the wafer for a semiconductor device being characterized in that a buffer layer formed of a layered compound having an excellent cleavage is provided between the substrate and the operation layer. (2) The present invention is a method of manufacturing a semiconductor device having an epitaxial operation layer, the method being

characterized in that after a buffer layer formed of a layered compound having an excellent cleavage is formed on a substrate, an operation layer is epitaxially grown on the buffer layer, and the operation layer and the substrate are peeled off from each other, thus it is joined to a new substrate. (3) The present invention is a method of manufacturing a semiconductor device having an epitaxial operation layer, the method being characterized in that a buffer layer formed of a layered compound having an excellent cleavage is formed on a grown substrate; the grown substrate is exposed by removing at least a portion of the buffer layer except for a device formation region; an operation layer is epitaxially grown on an exposed portion of the grown substrate and the buffer layer; only the device formation region is cut to be taken out; and the operation layer in the device region is peeled off from the grown substrate to be joined to a supporting substrate for the semiconductor device. The foregoing compound having the excellent cleavage used as the buffer layer should be the one in which layers are bonded with Van der Waals force (molecular bonding force). To be more specific,  $\text{MoS}_2$ ,  $\text{NbS}_2$ ,  $\text{MoSe}_2$ ,  $\text{NbSe}_2$ ,  $\text{GaSe}$ ,  $\text{SnS}_2$ ,  $\text{SnSe}_2$  and  $\text{InSe}_2$  are enumerated as the layered compound. Furthermore, as the grown substrate, a single crystal substrate having the same crystal structure as that of the operation layer should be used, and a crystal orientation of the substrate should be a (111) plane.

[0005]

[Operation] Fig. 1 is a sectional view of a wafer for a semiconductor device which is a concrete example of the present invention. A buffer layer 2 formed of a layered-like compound having an excellent cleavage is provided on a grown substrate 1. Subsequently, the operation layer 3 is formed. As to the semiconductor device, the device is formed in the operation layer 3 by use of a micro processing technology. Then, since the layers are bonded with the Van der Waals force in the buffer layer 2, it is possible to peel off the grown substrate 1 from the operation layer 3 by cleavage easily. In this peeling-off, an adhesion tape is adhered to the operation layer 3 or the grown substrate 1, and the grown substrate 1 can be easily peeled off from the operation layer 3 mechanically. Furthermore, when the layered compound of the operation layer 3 remains in the operation layer 3, the peeling-off operation is performed by use of the adhesive tape again, whereby it is possible to remove the grown substrate 1 thoroughly. The operation layer 3 obtained in the above-described manner is bonded to a supporting substrate for the semiconductor device such as a heat sink and a glass substrate, whereby the desired semiconductor device can be formed. The heat sink is for effectively discharging heat generated by the device to the outside, and a material having a high thermal conductivity is used as the heat sink. Diamond, beryllia, alumina or the like is used when the heat sink is an insulating material. Silicon or the like is used when the heat sink is a semiconductor. Gold, silver, copper or the like is used when the heat sink is a conductive material. Since such semiconductor device does not include a grown substrate at all, it is possible to reduce a heat resistance, and polishing and etching for removing a light absorption layer need not to be performed, and thus it was made possible to avoid the breakdown of an operation layer.

[0006] Fig. 2 is a plan view of a wafer for a semiconductor

device, which is another concrete example of the present invention. Fig. 3 is a sectional view taken along the line A-A of Fig. 2. A buffer layer 2 formed of a layered compound having an excellent cleavage is provided on a grown substrate 1, and portions of the buffer layer 2 except for a device formation region 4 are removed by etching them at suitable intervals with micro processing. Thus, a buffer layer removing region 5 is formed, and subsequently an operation layer 3 is formed on the grown substrate and the buffer layer 2 corresponding to the buffer layer removing region 5. Then, a chip of the device formation region 4 composed of the grown substrate 1, the layered compound buffer layer 2 and the operation layer 3 is obtained by cutting them along a dicing portion 6. Herein, since the layers of the layered compound are bonded by a Van der Waals force, it is possible to peel off the grown substrate 1 from the operation layer 3 easily by cleavage. Specifically, in the same manner as in the case of Fig. 1, the operation layer 3 is peeled off, and the semiconductor device is formed by bonding the operation layer 3 to a supporting substrate 7 for the semiconductor device.

[0007]

[Example] A GaSe buffer layer having a thickness of  $100\text{\AA}$  was grown on a GaAs (111) B plane substrate by an MBE method, and subsequently an operation layer composed of a p-AlGaAs window layer having a thickness of  $0.1\text{ }\mu\text{m}$ , a p-GaAs light absorption layer having a thickness of  $10\text{ }\mu\text{m}$  and an n-AlGaAs active layer having a thickness of  $0.3\text{ }\mu\text{m}$  was grown by the MBE method. Furthermore, an ohmic electrode and a Schottky electrode were formed on the surface thereof, thus fabricating a basic device of a CCD image sensor. By use of resin, a protection plate was adhered to the surface of the wafer where the device was formed, and an adhesion tape was adhered to the substrate to be mechanically peeled off. Since the buffer layer remained on the back surface of the operation layer, an adhesion tape was adhered thereto again to be peeled off. Thus, GaSe of the buffer layer could be removed thoroughly. The operation layer obtained was joined to a glass substrate, and a basic device of a CCD image sensor was formed. When the characteristics of this device was examined, a dark current thereof was substantially not less than that of a conventional device fabricated by removing a substrate thoroughly by etching. The obtained device stood comparison therewith.

[0008]

[Effects of the Invention] The present invention adopts the foregoing constitution, whereby it is possible to peel off and recover only the operation layer without damaging the operation layer. Accordingly, it is possible to manufacture high quality semiconductor devices with a high yield.

[Brief Description of the Drawings]

[Figure 1] Fig. 1 is a sectional view of a wafer of a semiconductor device which is one concrete example of the present invention.

[Figure 2] Fig. 2 is a plan view of a wafer for a semiconductor device which is another concrete example of the present invention.

[Figure 3] Fig. 3 is a sectional view taken along the line A-A of Fig. 2.

[Figure 4] Fig. 4 is a sectional view of the wafer in which an operation layer is bonded to a supporting substrate for the semiconductor device.

[Figure 5] Fig. 5 is a sectional view of a conventional wafer for a semiconductor device.

Fig.1

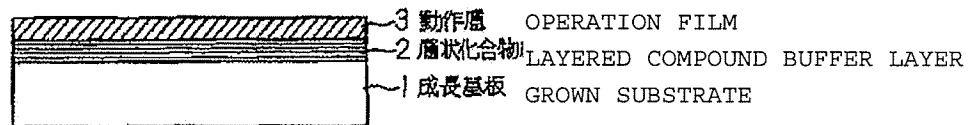


Fig.2

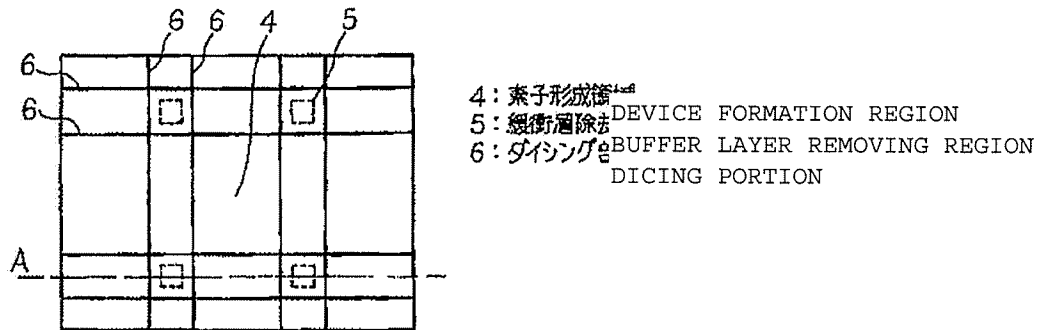


Fig.3

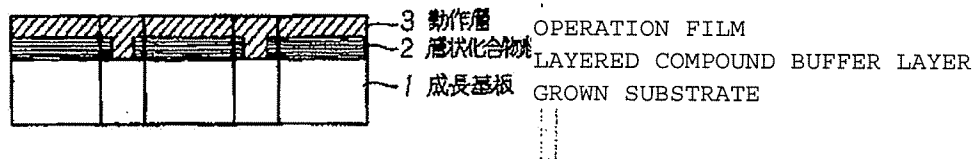


Fig.4

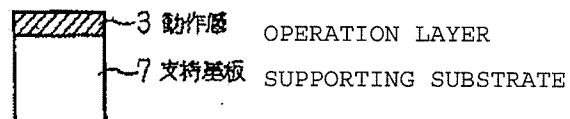


Fig.5



- 1 GROWN SUBSTRATE
- 2 LAYERED COMPOUND BUFFER LAYER
- 3 OPERATION FILM

FIG. 1

- 1 GROWN SUBSTRATE
- 2 LAYERED COMPOUND BUFFER LAYER
- 3 OPERATION FILM

FIG. 2

- 4 DEVICE FORMATION REGION
- 5 BUFFER LAYER REMOVING REGION
- 6 DICING PORTION

FIG. 3

- 1 GROWN SUBSTRATE
- 2 LAYERED COMPOUND BUFFER LAYER
- 3 OPERATION FILM

FIG. 4

- 3 OPERATION LAYER
- 4 SUPPORTING SUBSTRATE

FIG. 5

- 8 GROWN SUBSTRATE
- 9 BUFFER LAYER
- 10 OPERATION LAYER